PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	Pierre H. Woerlee Gert Hooft Jisk Hollcman	Examiner:	Monica D. Harrison
Serial No.:	10/534,385	Group Art Unit:	2813
Filed:	May 6, 20050	Docket No.:	**NL02 1147 US**

Title: SILICON LIGHT EMITTING DIODE

Declaration Under 37 C.F.R. § 1.131

I, Gert Hooft, hereby present the following declarations.

Before September 19, 2002, while working with others (Pierre Woerlee and I being employed at Koninklijke Philips Electronics N.V. and Jisk Hollcman being employed at the University of Twente but working in cooperation with Koninklijke Philips Electronics N.V.):

1. I, along with Pierre Woerlee and Jisk Holleman, invented and designed the structure and method as claimed in the above identified patent application. The invention included a structure and method for creating a radiation-emitting semiconductor device that includes a semiconductor body and a substrate, which silicon-containing semiconductor device has a lateral semiconductor diode which is situated on an insulating layer that separates the diode from the substrate. The lateral semiconductor diode successively comprises a first semiconductor region of a first conductivity type and with a first doping concentration, a second semiconductor region of the first or a second conductivity type opposite to the first conductivity type and with a second doping concentration that is lower than the first doping concentration, and a third semiconductor region of the second conductivity type and with a third doping concentration that is higher than the second doping concentration, the first and the third semiconductor region each being provided with a connection region. During operation, radiation is generated in the second semiconductor region as a result of recombination of charge carriers injected from the first and

the third semiconductor region in the second semiconductor region, wherein the second semiconductor region comprises a central portion that is surrounded by a further portion the bandgap of which is larger than that of the central portion.

2. I, along with the other inventors, prepared a six-page invention disclosure statement, a true and accurate copy of which is attached hereto as an Exhibit, with pertinent dates intentionally blocked out (each date preceding September 19, 2002) and certain confidential information blacked out and marked "CONFIDENTIAL." The Embodiment of the Invention section on page 4 and accompanying figures of the Exhibit provide further details as to the extent of our invention. The work described above and shown in the Exhibit was performed in the Netherlands. This invention disclosure statement provides details of the efficient light emitting device (LED) in silicon technology that I assisted in inventing and designing.

3. This invention disclosure statement was submitted to the Intellectual Property & Standards Division (formerly known as Corporate Intellectual Property) of Koninklijke Philips Electronics N.V. on February 25, 2002 (before the date of September 19, 2002), and was subsequently used in the preparation of the above-referenced patent application, which was first filed on November 7, 2002 as a European provisional patent application. This patent application entered the United States Patent and Trademark Office as a national stage patent application on May 6, 2005. Diligence was exercised by me, the other inventors, and the Intellectual Property & Standards Division in the searching, drafting, reviewing, and filing of the patent application in the time period between February 25, 2002, and the filing date of November 7, 2002.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed this 25 day of October 2006 by: _____

Gert Hoofman

EXHIBIT

Invention Disclosure

This form and an annex containing a detailed description of the invention should be forwarded to Mr. Nico van Barschot, Tel.: + 31 40 27 44308, Corporate Intellectual Property, building WAH, Prof. Holstlaan 6, 5656 AA Eindhoven, The Netherlands, nico.van.barschot@philips.com.

Date:	Business Unit	To be filled in by Corporate Intellectual Property
02/25/02 11:48:41	Nat.Lab.	Date: 02/25/02 14:07:16 ID-number: 609483

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Title of the Invention
Silicon Light Emitting Diode

Summary of the Invention:
There is a strong demand for an efficient light emitting device (LED) in silicon technology. Recently Silicon LEDS with relatively high efficiency were reported for bulk silicon. In this invention a silicon LED fabricated in Silicon On Insulator (SOI) material is presented. Advantages of SOI are the possibility of band-gap engineering and full dielectric isolation. This enables electron and hole confinement. Furthermore tuning of the wavelength by quantum size effects is possible.

Detailed description of the Invention on annexes; please describe preferred embodiments and their advantages over prior solutions in detail; please include drawings. (See page 2)

Stage and Importance of the Invention a. Stage of the invention?	CONFIDENTIAL
b. In what products, processes or systems could the invention be used?	CONFIDENTIAL
c. For which other business units of Philips could the invention have relevance?	CONFIDENTIAL
d. For which competitors of Philips could the invention have relevance ? Why?	CONFIDENTIAL
e. For which LRTD(s) could the invention have relevance?	CONFIDENTIAL
Distribution of Information concerning the Invention When, how and where will information concerning the invention be distributed outside Philips? Please consider publications, headings, exhibitions, offers, contacts with potential customers or suppliers, issuing of samples. **N.B. Even after sending this Invention Disclosure to Philips Corporate Intellectual Property, any such acts will impair patentability of the invention. Please contact Philips Corporate Intellectual Property before information concerning the invention leaves Philips.**	CONFIDENTIAL
Supplemental information concerning the Invention a. Is the invention the result of a cooperation with persons outside Philips? If so, with whom?	CONFIDENTIAL
b. Is there, or will there be, an internal report on the invention? If so, please state the number.	CONFIDENTIAL
c. Are there, or will there be, other invention disclosures relating to this invention? If so, please state Ref.no.	CONFIDENTIAL

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d Are there other persons who could give information on the invention? If so, who?	CONFIDENTIAL
Recommendation inventor as to urgency, commercial importance, and competitors' activities.	CONFIDENTIAL

Available Attachments (downloadable via web application)
silicon_led.doc

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An efficient silicon Light-Emitting Device

P.H. Woerlee, G.W. 't Hooft (Philips Research Labs)

J. Holleman (University of Twente)

State of the Art

CONFIDENTIAL 1

Objective/Problem

CONFIDENTIAL 2

The measures that are proposed to solve the problem, and the resulting advantages

CONFIDENTIAL 3

Embodiment of the invention

An overview a lateral stripe diode fabricated on SOI is presented in figure 2. The left contact (on highly n-doped silicon) injects electrons in the neutral region. The right contact is heavily p-doped silicon, from here holes are injected in the neutral region. In the neutral region electrons and holes recombine, and light emission occurs. The efficiency is increased by the e-h confinement (see fig 2.). The material quality of SOI and its interfaces is excellent (there is a large effort to improve SOI quality for microprocessor fabrication). Hence the non-radiative recombination rate should be low.

An embodiment of the invention is described below. Standard thin-film SOI (Smart-Cut or SIMOX) with Si thickness around 150 nm and buried oxide thickness around 300 nm is used in the device fabrication (fig 3a). In the first step the device isolation (for example shallow trench isolation (STI)) is performed (fig 3b). This is needed to have full dielectric isolation. Furthermore STI is necessary anyhow when CMOS devices are processed with the Si-LED. Their ultra-thin film SOI ($T_{Si} < 10$ nm) needs to be fabricated to confine the carriers by bandgap engineering. This can be done either by two anisotropic etching or by two LOCOS like oxidation steps (figure 3c, 3d). The latter procedure is preferred because it is a more robust process for forming of ultra-thin SOI (the oxidation is almost self limiting). Thereafter the n+ and p+ contact areas (3e) are formed by ion implantation (the source/drain implantations of the CMOS technology could be used). The process ends by a standard metallisation (fig. 1).

The fields of application of the invention.

CONFIDENTIAL

References

[1] L. Pavesi et al., Nature 408, pp 440 (2000).
[2] W.L. Ng et al., Nature 410, 192-194 (2001).
[3] M.A. Green et al., Nature 412, 805 (2001).

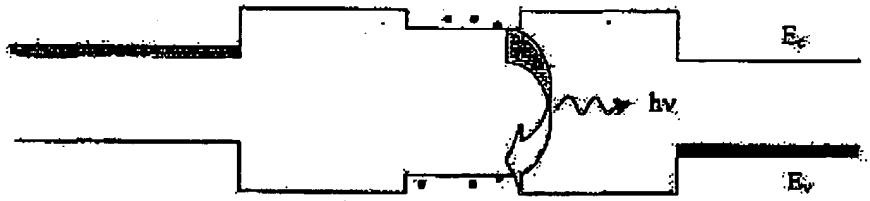


Figure 1: Schematic drawing of band diagram of lateral Si-LED

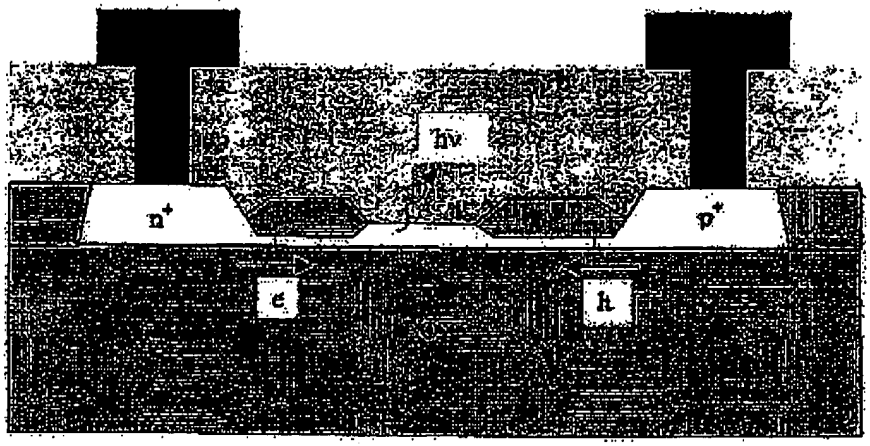
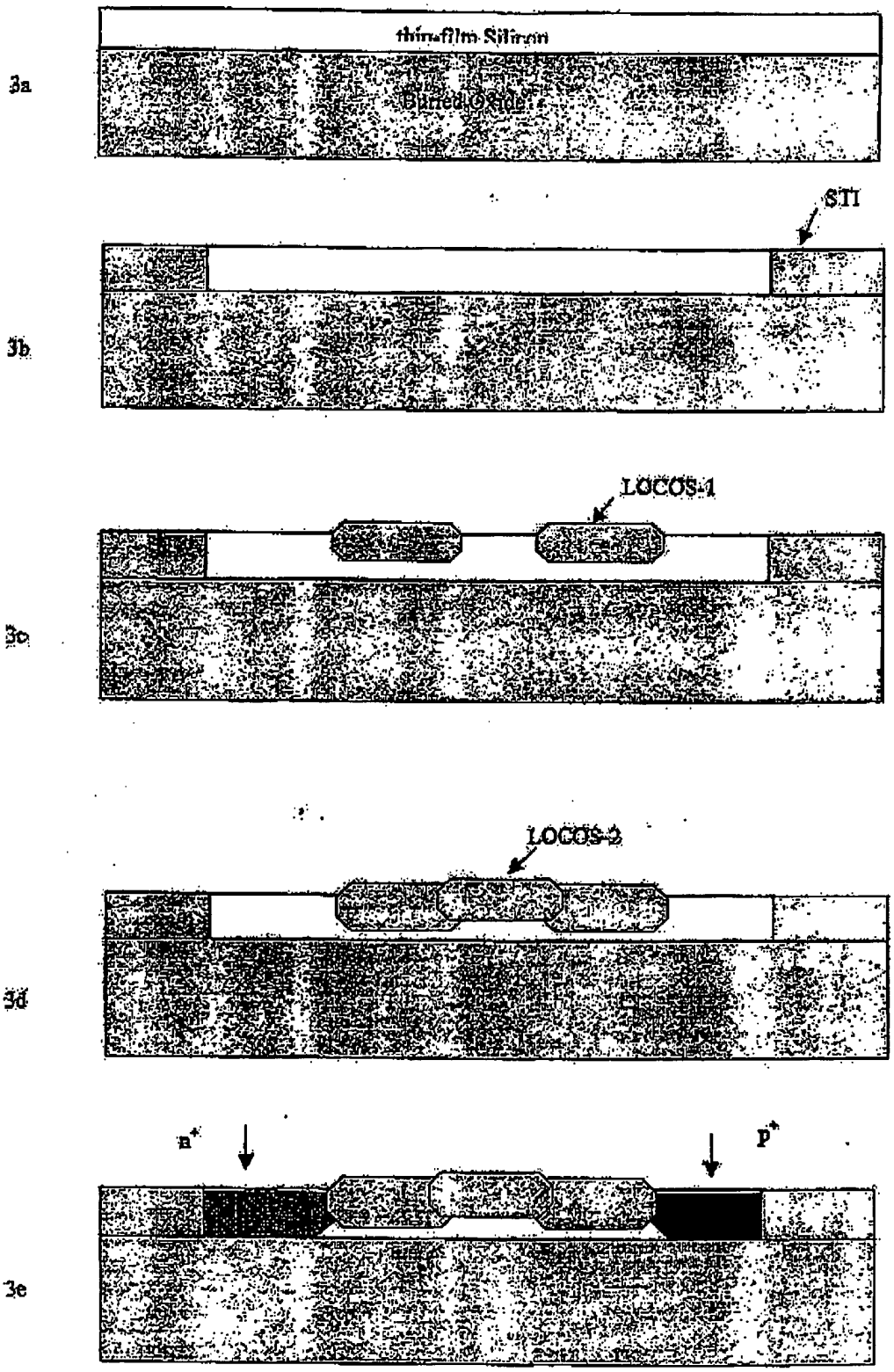


Figure 2: Schematic drawing of SOI-LED


thin-film Silicon
Buried Oxide
3a
STI
3b
LOCOS-1
3c
LOCOS-2
3d
n+
p+
3e